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ABSTRACT

The cognitive and affective domains of learning outcomes--i.e., intellectual skills, verbal information, cognitive strategies, and attitudes--are parts of every schema. Located within an individual schema, these capabilities are interrelated, and acquiring one capability is likely to have an effect on other types of capabilities within the same schema. The central role of the intellectual skills domain and advantages of integrating various outcome domains, also known as accompanying objectives, have implications for instructional design. General types of accompanying objectives include: (1) the terminal objective, i.e., the ability to perform the skill; (2) knowing when the skill can be applied; (3) the ability to use the skill when needed; and (4) choosing to use the skill. The use of a generic instructional curriculum map (ICM) to present interrelationships among the related objectives from various outcome domains may help the instructional designer to select instructional strategies, and to determine the sequence of instruction among objectives. Fifteen references are listed. (MES)

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Schema Theory: A Basis for Domain Integration Design

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Schema Theory: A Basis for Domain Integration Design

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In recent years, human cognition and knowledge structure have been extensively investigated in terms of schemata (e.g., Anderson, 1984a; Rumelhart, 1980). Schemata are claimed to be the basic units of human knowledge. A schema is defined as "an organized body of knowledge, conceived theoretically as a set of interconnected propositions centering around a general concept, and linked peripherally with other concepts (Gagné, 1986, p. 12)". It has been demonstrated by schema research (e.g., Pichert & Anderson, 1977) that the schemata existing in a person's knowledge structure influence the way newly-coming information is interpreted and acquired.

Schema theory explains internal conditions of learning, which can be applied in instructional design in various ways. In this paper, schematic interpretation of human cognition is first related to human capabilities, for which instruction is designed. Then, instructional implication of the schema theory will be discussed for integration of learning outcome domains. Finally, procedures for the design of instruction will be suggested emphasizing integration of various outcome domains.

A Schema and Associated Domains of Learning Outcomes

In order to relate schematic representation of human knowledge and instructional design, it is helpful to describe a schema in terms of the domains of learning outcomes; intellectual skills, verbal information, cognitive stragegies, attitudes, and motor skills (Gagné, 1985). The domain of learning outcomes must be identified for each objective in instruction because it informs an instructional designer of a distinctive set of effective instructional strategies. In this sense, analyzing a schema into the domains of learning outcomes may enable us to identify what exactly a schema is, in relation to how we can facilitate the learning of it.

A schema is said to be formed around a general concept, which belongs to the domain of intellectual skills. Concepts are intellectual skills in that they provide rules for classifying incoming information (Gagné, 1985). Such a function is known as "ideational scaffolding (Anderson, 1984a)", for which the "slot" structure of a schema is utilized. For example, if one has a schema for "monument", he or she can tell if a given description is about a monument or not by

applying such classification rules as "Is it a structure (such as a building or sculpture)?" and "Is it for a memorial?" If the slot for the memorial cannot be filled out by a person or event from the description, then the example may not be considered to be a monument, but a mere building. Thus, by using the monument schema, and other related schemata, one can classify instances of monuments and other related concepts (e.g., ordinary buildings, memorial holidays).

A schema also contains individual examples of the schema, which are in the verbal information domain. A schema has accumulated instances of the general concept. These instances are known as "instantiations" of the schema (Anderson, 1984a). For example, the "monument schema" may contain the facts about the Washington Monument as an instantiation; about its location, history, configuration, and to whom it is dedicated. Other related information may be associated with the monument schema, including episodic facts (e.g., when the learner saw the monument, with whom, the weather of the day, etc.), and historical notes of the dedicator.

Another type of cognitive capability is associated with a schema, which can be classified in the domain of cognitive strategies. Cognitive strategies control internal information-processing, which are also known as "metacognition", or more specifically, "self-regulatory mechanisms used by an active learner" (Armbruster & Brown, 1984, p. 274). Each schema not only has intellectual skills and verbal information, but also is equipped with cognitive strategies. Rumelhart (1980) has stated: "Embedded in these packets of knowledge [i.e. schemata] is, in addition to the knowledge itself, information about how this knowledge is to be used" (p. 34). Although cognitive strategies for general uses may be located elsewhere, the strategies employed mainly for the learning about monuments (i.e. domain specific strategies) is best placed within the monument schema.

It is natural to assume that attitudes are related to schemata, toward which the attitudes are formed. Schemata are formed around general concepts of objects, situations, and events. Attitudes are "internal states that influence the individual's choice of personal action [toward some category of objects, persons, or events]" (Gagné, 1985, p. 219). Thus, each schema is likely to be accompanied with an affective proposition about that schema, which influences personal choices associated with the schema. If a person is not interested in history in general, he or she may not choose to visit or study about monuments, for example. A student of history and of architecture may develop

very different schemata of monuments because of their different interests. Although knowing something is different from liking something, attitudes seem to be a part of schemata.

In short, both cognitive and affective domains of learning outcomes seem to be parts of each schema. That is, a schema may be related to capabilities of intellectual skills, verbal information, cognitive strategies, and attitudes. Located within an individual schema, these various capabilities are related to each other. Acquiring one capability is likely to have an effect on other types of capabilities within the same schema.

From Schema Theory To Domain Integration Design

Gagné's (1985) distinction between the domains of verbal information and intellectual skills can be made parallel to the types of learning processes proposed by schema theorists. When verbal information is learned, no change in schema structure is necessary; in-coming information will be assimilated to an existing schema using existing "slots" of the schema. If you learn about a monument in Japan, for example, you will use the same fact categories that are used to learn about the Washington Monument: its location, history, configuration, and to whom it is dedicated. In other words, the existing "monument schema" will be activated (Bransford, 1984) to assimilate another instantiation of the schema. Rumelhart and Norman (1978) have called this process "accretion".

In contrast, when a child learns what a monument is, he or she is acquiring the slots in "monument schema". The Washington Monument may be used to exemplify the classification rules of the monument concept. However, it is not the main objective of the learning to be able to state the facts about the Washington Monument. Instead, the objective is to organize the "monument schema" so that new information can be judged as to wether it is about another monument or not. This process involves either tuning up the existing "monument schema", which is not yet well-articulated, or creating a new "monument schema" by using existing similar schemata.

Schema theory appears to be compatible with the notion of intellectual skills as building blocks for the design of instruction (Gagné & Briggs, 1979). Rumelhart and Norman (1978) have distinguished these processes of the evolution of existing schemata (tuning) and the creation of new ones (restructuring) as different modes of learning from the accretion process. These authors have also argued that the

tuning and restructuring processes are not as frequent as accretion, but more significant. Without a change in schema structure, new concepts cannot be formed. On the other hand, when an intellectual skill is learned, the basic structure of the schema surrounding that skill is formulated. Because the memory structure is built by interrelated schemata, instruction may best be planned for finishing up such a structure when a lesson, or section is completed.

Even when a target objective is not an intellectual skill, it may be advantageous to relate the target objective to an intellectual skill objective. That is, try to identify and help formulating a more structured schema surrounding that target objective by adding related intellectual skill objectives. For example, the terminal objective for a math lesson may be to memorize conversion formulas among metric units of length, area, and volume measurements. The learners could try to memorize all individual formulas (e.g., 1 m^2 = 10000 cm^2). However, after studying the formulas for length, the learners can be introduced to a rule that relates length with area and volume. Once this rule is acquired, the learner does not need to remember all of the formulas, but only the formulas for length and how to apply them for area and volume (e.g., 1 m = 100 cm; thus, 1 m^2 = 1 m x 1 m = 100 cm x 100 cm = 100 x 100 cm^2 = 10000 cm^2).

A more structured schema, which includes more intellectual skills, will enable the learner to transfer the structure to formulate another schema when needed. The more structured a schema becomes, the more useful it is for further learning. Anderson (1984b) has pointed out that school education is likely to reinforce the "weak" views of knowledge by teaching individual facts separately. By using intellectual skills as the building blocks of curriculum, we may also be able to support a strong view of knowledge, with which the learners will try to utilize what they know in a constructive manner.

Another implication from the schema theory is to integrate various domains of learning outcomes, which presumably are associated with the schema of the terminal intellectual skill objective. The basic units of memory structure are schemata, and each of the schemata is more than its core intellectual skill. Therefore, other related capabilities can also be learned to make the new learning more complete.

For the sake of argument, such capabilities may be called as "accompanying objectives". Instruction would be designed for an intellectual skill terminal

objective and its accompanying objectives. The accompanying objectives are NOT subordinate to the terminal objective in the sense of "essential prerequisites", the absence of which disable the learning of the terminal objective. Although these related capabilities may support the learning of the terminal objective (i.e., "supportive prerequisites"), the accomplishment of the accompanying objectives are, for themselves, terminal. The teminal intellectual skill objective plus the accompanying objectives may represent more complete schema than the intellectual skill alone.

Various types of accompanying objectives have been proposed in the literature in several different terms. White and Mayer (1980) proposed a classification system of verbal information related to the learning of an intellectual skill into productive and unproductive types. Accompanying cognitive strategies have been investigated by the learning strategy researchers. Derry and Murphy (1986) have proposed that the learning of cognitive strategies be embodied into the cognitive skill and knowledge instruction after the initial exposure to the strategies. An intellectual skill and an accompanying attitude are called "twin objectives" by Briggs and Wager (1981), who have suggested the inclusion of an attitude counterpart of the target objective in lesson and unit design. Other related affective outcomes have been integrated in design of cognitive outcome domains by Martin and Briggs (1986) and Keller (1983).

Given a specific lesson objective, one may be able to derive accompanying objectives by seeking a more complete schema. To follow Gagné's approach in constructing learning hierarchies, a question can be asked: "What else can the learner learn in order to enhance the schema related to the target intellectual skill objective, absence of which restricts the utilization of the target skill?" The target objective alone will be sufficient for a learner to demonstrate the skill when and if so asked. However, the accompanying objectives will help in enhancing the surrounding schema, with which the target skill may better be utilized for practical situations, or for related learning tasks. In other words, when this question is asked, not only the end-of-lesson accomplishments, but also long-term effects should be taken into consideration.

In order for the target skill to be utilized, a learner must be able to perform the skill. In addition, there seem to be several other general types of the accompanying capabilities. The learner must:

(1) be able to perform the skill (terminal objective).
(2) know when the skill can be applied (contextual knowledge; verbal information).
(3) be able to use the skill when needed (initiating internal processes; cognitive strategies).
(4) choose to use the skill (positive attitude toward using the skill).

In Figure 1, these terminal and accompanying objectives, and some other supporting objectives are summarized in the form of a generic Instructional Curriculum Map (ICM, Briggs & Wager, 1981). The ICM presents hypothesized interrelationships among the related objectives from various outcome domains. It should be helpful for an instructional designer to visualize how objectives from different domains of learning outcomes may help each other. It may be used to select instructional strategies, as well as to determine the sequence of instruction among the depicted objectives.

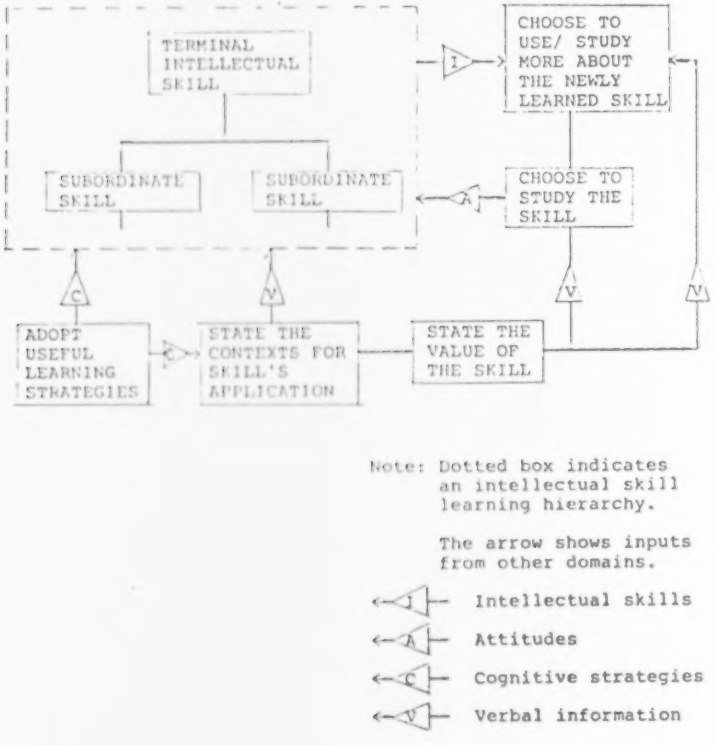

Figure 1. Generic ICM Summarizing Accompanying Objectives.

Concluding Remarks

Looking at the schema theory of human cognition, this paper discussed some implications for designing instruction. These implications include the central role of the intellectual skills domain in learning and the advantages of integrating various outcome domains in instructional design. The notion of accompanying objectives was proposed to design an instructional segment for a richer learning outcome, which presumably represents a more complete state of the surrounding schema. Instructional Curriculum Maps are employed as visual representations for integrating various domain of learning outcomes in design effort.

In order to apply the two implications emerged from the schema theory, the procedures for the instructional design will be as follows:

1. Define the lesson objective. If the lesson objective is not an intellectual skill, find a related intellectual skill.
2. Lay out essential subordinate skills, constructing a learning heirarchy.
3. Explore accompanying objectives that help utilizing the teminal skill. The generic ICM (Figure 1) may be helpful at this point.
4. Lay out the accompanying objectives and other supportive objectives, forming an ICM.
5. Determine the instructional strategies for the terminal objective taking other objectives into account.

It is the presenter's hope that a strong view of knowledge (Anderson, 1984b) will be emphasized in as many occasions as possible whenever an instructional segment is systematically designed. To accomplish that end, it seems to be a good course of action to emphasize the domain of intellectual skills and also to take other types of learning outcomes into account. By integrating various outcome domains in instructional design, we can also develop positive attitudes toward learning, knowledge for applying the learned skills, and strategies for learning within the instruction emphasizing the learning of intellectual skills.

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